Application Note: SQ24301

Super Low Dropout 1A LDO Regulator

Advanced Design Specification

General Description

The SQ24301 is a super low dropout LDO regulator with small package, capable of delivering up to 1A output current.

Ordering Information

SQ24301 □(□□□)

- Package Code (the last three boxes)
- Optional Spec Code (the first box)

Ordering Number	Package type	Note
SQ24301DSD	DFN3×3-6	----

Features

- Input Voltage Range: 1.6-5.5V
- Output Voltage Accuracy: ±5%
- Up to 1A Output Current
- Low Dropout Voltage:
  Typ. 0.32V at I_{OUT}=1A, V_{OUT}=1.5V
  Typ. 0.18V at I_{OUT}=1A, V_{OUT}=2.8V
- Current Limiting Protection
- Thermal Shutdown Protection
- Quiescent Current: 60µA
- Output Auto-discharge Function
- Over Temperature Protection
- RoHS Compliant and Halogen Free
- Compact Package: DFN3×3-6

Applications

- Portable Communication Equipments
- Hand-Held Instruments, Notebook PC
- Camcorders and Cameras

Typical Applications

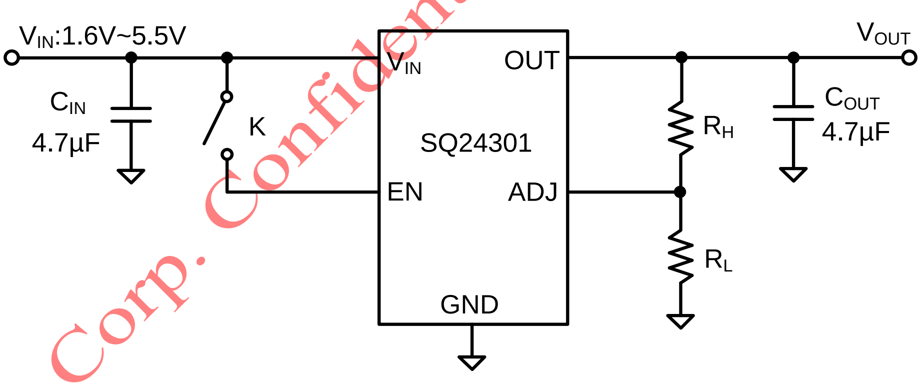
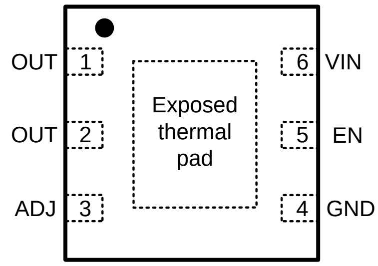


Figure1. Schematic Diagram

Pinout (top view)



(DFN3×3-6)

Top mark: 8Txyz for SQ24301DSD (Device code: 8T, ***x=year code, y=week code, z= lot number code***)

Pin Name	Pin Number	Pin Description
OUT	1, 2	Output pin. Decouple this pin to the GND pin with at least a 4.7μF ceramic capacitor.
ADJ	3	Output voltage programming pin. Connect this pin to the center point of the output resistor divider (as shown in Figure 1) to program the output voltage: $V_{OUT}=1.0V\times(1+R_H/R_L)$.
GND	4	Ground pin.
EN	5	Enable control pin. A 5MΩ pull-down resistor is integrated.
VIN	6	Input pin. Decouple this pin to the GND pin with at least a 4.7μF ceramic capacitor.

Block Diagram

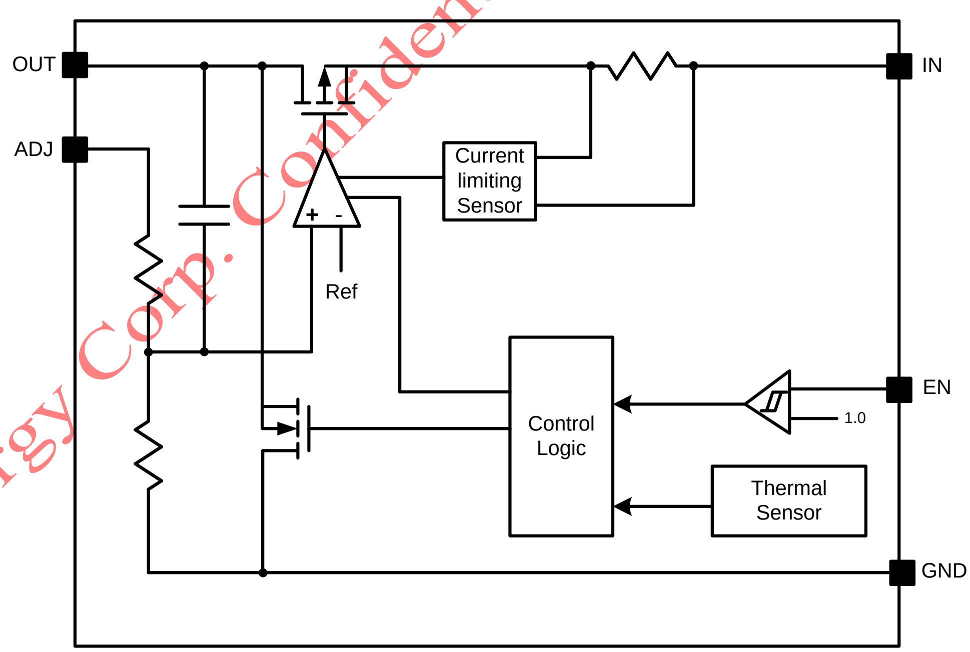


Figure2. Block Diagram

Absolute Maximum Ratings (Note 1)

IN, EN -- 6.0V

Power Dissipation, P_D @ T_A = 25℃ DFN3×3-6 --- 2W

Package Thermal Resistance (Note 2)

θ_{JA} -- 50℃/W

θ_{JC} -- 15℃/W

Junction Temperature Range -- 150℃

Lead Temperature (Soldering, 10 sec.) --- 260℃

Storage Temperature Range -- -65℃ to 150℃

Recommended Operating Conditions (Note 3)

Supply Input Voltage -- 1.6V to 5.5V

Junction Temperature Range -- -40℃ to 125℃

Ambient Temperature Range --- -40℃ to 85℃

Electrical Characteristics

(V_{IN} = 5V, C_{IN}=4.7μF, C_{OUT}=4.7μF. T_J = -40℃ to +125℃. Typical values are at T_J = 25℃, unless otherwise specified. The values are guaranteed by test, design or statistical correlation.)

Parameter	Symbol	Test Conditions	Min	Typ.	Max	Unit
Input Voltage Range	V_{IN}		1.6		5.5	V
Supply Current	I_{SS}	V_{EN}=V_{IN}=2V, V_{OUT}=V_{ADJ}, I_{OUT}=0A		60	100	μA
Shutdown Current	I_{SD}	V_{IN}=6.0V, V_{EN}=0		0.1	10	μA
Output Voltage Accuracy	ΔV_{OUT}	V_{OUT}=V_{ADJ}, V_{IN}=2.0V, I_{OUT}=100mA	0.95		1.05	V
Output Voltage Range			1.0		V_{IN}	V
Current Limit	I_{LIM}		1.0			A
Load Regulation	$\Delta V_{OUT}/\Delta I_{OUT}$	V_{OUT}=V_{ADJ}, V_{IN}=2.0V 1mA≤I_{OUT}≤1A		-3		mV/A
Line Regulation	$\Delta V_{OUT}/$ ΔV_{IN}	V_{OUT}=V_{ADJ}, I_{OUT}=100mA 2.0≤V_{IN}≤5.5V		0.05	0.3	%/V
EN Pull-down Resistance	R_{EN}			5		MΩ
Ripple Rejection	RR	f=1kHz, Ripple 0.5V_{P-P} V_{OUT}=V_{ADJ}, V_{IN}=2.5V, I_{OUT}=100mA		-60		dB
Output Voltage Temperature Coefficient	$\Delta V_{OUT}/\Delta T$	I_{OUT}=100mA -40℃≤T_J≤85℃		±100		ppm/℃
Short Current Limit	I_{SHORT}	V_{OUT}=0V		250		mA
Discharge Resistor	R_{DISCHG}			100		Ω
EN Rising Threshold	V_{ENH}		1.0			V
EN Falling Threshold	V_{ENL}				0.3	V
Thermal Shutdown Temperature (Note 4)	T_{SD}			150		℃
Thermal Shutdown Hysteresis (Note 4)	T_{HYS}			20		℃
Dropout Voltage	V_{DROP}	Refer to following table				

Dropout Voltage by output Voltage

T_J = -40 ℃ to +125 ℃.

Output Voltage(V) V_{OUT}	Dropout Voltage V_{DROP} (V)		
	I=300mA		I=1A
	Typ.	Max	Typ
1.0V≤V_{OUT} < 1.5V	0.18	0.32	0.50
1.5V≤ V_{OUT} < 2.6V (Note 4)	0.10	0.15	0.28
2.6V≤V_{OUT} (Note 4)	0.05	0.10	0.18

Note 1: Stresses beyond the "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

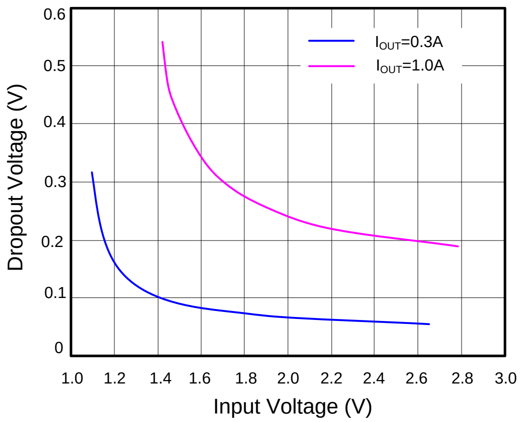
Note 2: θ_{JA} is measured in the natural convection at T_A = 25 ℃ on a two-layer Silergy evaluation board.

Note 3: The device is not guaranteed to function outside its operating conditions.

Note 4: Guaranteed by design.

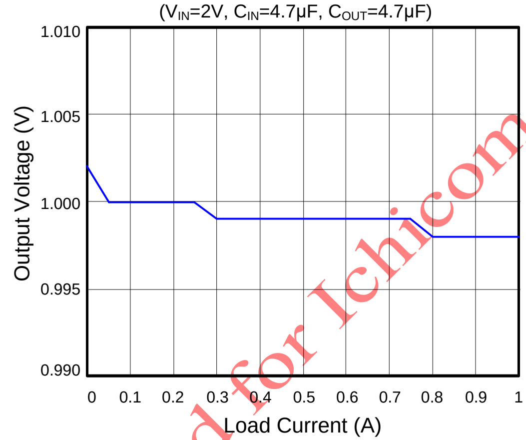
Typical Operating Characteristics

Dropout Voltage vs. Input Voltage



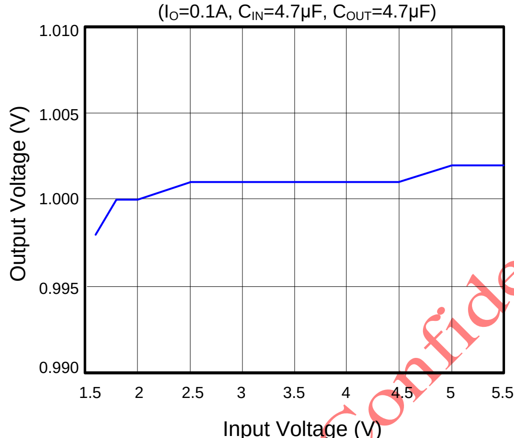
Load Regulation

(V_{IN}=2V, C_{IN}=4.7μF, C_{OUT}=4.7μF)



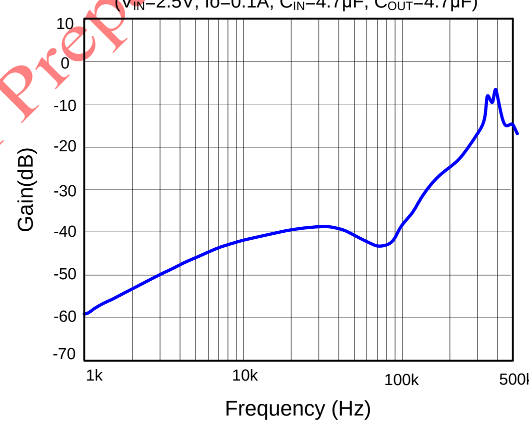
Line Regulation

(I_O=0.1A, C_{IN}=4.7μF, C_{OUT}=4.7μF)



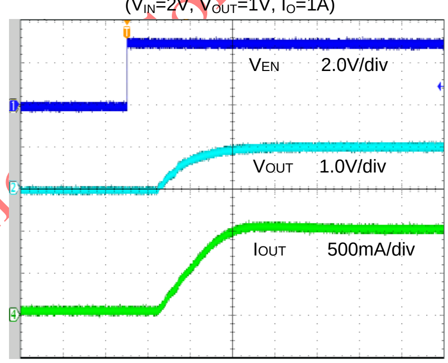
Power Supply Rejection Ratio

(V_{IN}=2.5V, Io=0.1A, C_{IN}=4.7μF, C_{OUT}=4.7μF)



Startup from EN

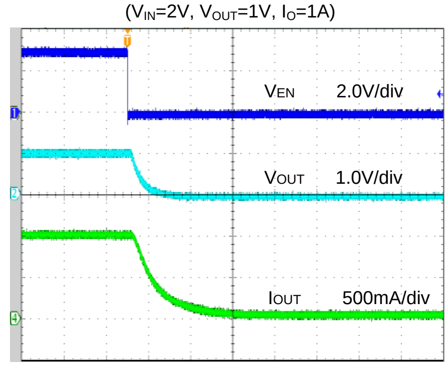
(V_{IN}=2V, V_{OUT}=1V, I_O=1A)



Time (20μs/div)

Shutdown from EN

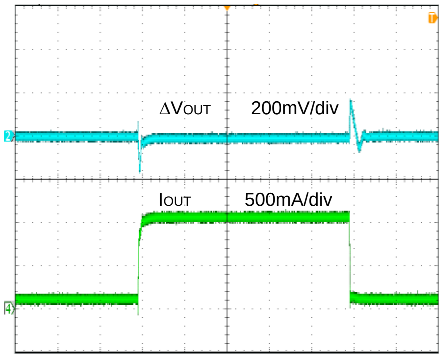
(V_{IN}=2V, V_{OUT}=1V, I_O=1A)



Time (10μs/div)

Load Transient

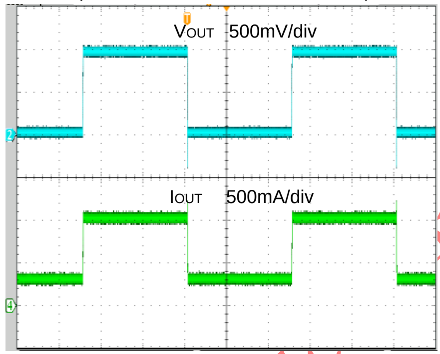
(V_{IN}=2V, V_{OUT}=1V, I_O=0.1~1A)



Time (40μs/div)

Short Circuit Protection

(V_{IN}=2V, V_{OUT}=1V, 1A to hard short)



Time (2ms/div)

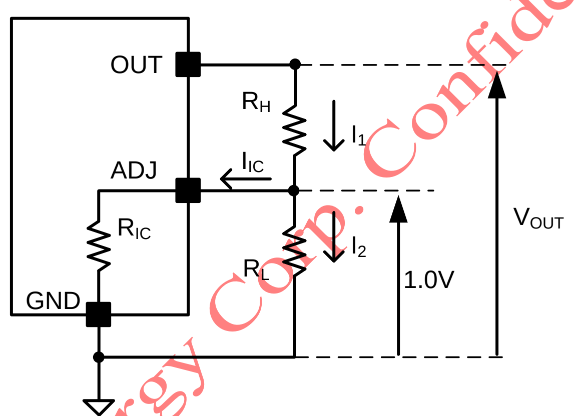
Operation Information

The SQ24301 is a super low dropout LDO regulator with small package, capable of delivering up to 1A output current.

Input Capacitor C_{IN}:
An input capacitor about 4.7µF is required between the device input pin and ground pin. A typical X5R or better grade ceramic capacitor with 6V rating is recommended in this application. This input capacitor must be located close to the device to assure the input stability. A lower ESR capacitor allows the use of less capacitance, while higher ESR type requires more capacitance.

Output Capacitor C_{OUT}:
For transient stability, the SQ24301 is designed specifically to work with very small ceramic output capacitors. A 4.7µF input capacitor with 10mΩ to 50mΩ ESR range (like X7R or X5R) can be used in this application. Higher capacitance values help to improve transient. The output capacitor's ESR is critical because it forms a zero to provide phase lead which is required for loop stability.

Output Voltage Setting:



The Output Voltage may be adjustable for any output voltage between its 1.0V reference and its VIN setting level. An external pair of resistors is required, as shown above.
The complete equation for the output voltage is described as follows;

$V_{OUT}=1.0+R_H(I_{IC}+1.0/R_L)$;
Thus, $V_{OUT}=1.0(1+R_H/R_L)+R_H\times I_{IC}$;
Therefore, $R_H\times I_{IC}$ will produce an error in V_{OUT}.

For better accuracy, choosing $R_L<<R_{IC}$ (1.45MΩ) reduces this error.

So, $V_{OUT}=1.0(1+R_H/R_L)$, ($R_L<<R_{IC}$).

No Load Stability:
The device will remain stable and in regulation with no external load. This is especially important in CMOS RAM keep-alive applications.

Dropout Voltage:
The SQ24301 has a very low dropout voltage due to its extra low $R_{DS(ON)}$ of the main PMOS determines the lowest usable supply voltage. In battery-powered systems, the dropout voltage is a regulator's minimum V_{IN}-V_{OUT}, which determines the useful end-of-life battery voltage:

$$V_{DROPOUT}=V_{IN}-V_{OUT}=R_{DS(ON)}\times I_{OUT}$$

Current Limit:
The minimum current limit of the SQ24301 is 1A.

Short-circuit Protection
The device is short circuit protected and in the event of a peak over-current condition, the short-circuit control loop will rapidly drive the output PMOS pass element off. The thermal shutdown and soft-start circuit will works cycle output on and off until the average power dissipation causes the thermal shutdown circuit to respond to servo the on/off cycling to a lower frequency.

Thermal Considerations:
The SQ24301 can deliver a current of up to 1A over the full operating junction temperature range. However, the maximum output current must be derated at higher ambient temperature to ensure the junction temperature does not exceed 125℃. With all possible conditions, the junction temperature must be within the range specified under operating conditions. Power dissipation can be calculated based on the output current and the voltage drop across regulator.

$$P_D=(V_{IN}-V_{OUT})\times I_{OUT}+V_{IN}\times I_{GND}$$

The final operating junction temperature for any set of conditions can be estimated by the following thermal equation:

$$P_{D(MAX)}=(T_{J(MAX)}-T_A)/\theta_{JA}$$

Where $T_{J(MAX)}$ is the maximum junction temperature of the die and T_A is the maximum ambient temperature.

Layout Design:

Good board layout practices must be used or instability can be induced because of ground loops and voltage drops, and large PCB copper area can improve the thermal performance. The input and output capacitors MUST be directly connected to the input, the output, and the ground pins of the device using traces which have no other currents flowing through them. The feed back loop formed by R_L, R_H and the trace connecting to the ADJ pin and the OUT must be minimizing.

The best way to do this is to layout C_{IN} and C_{OUT} near the device with short traces to the V_{IN}, V_{OUT}, and ground pins. The regulator ground pin should be connected to the external circuit ground so that the regulator and its capacitors have a “single point ground”.

Below is the recommended PCB Layout diagram:

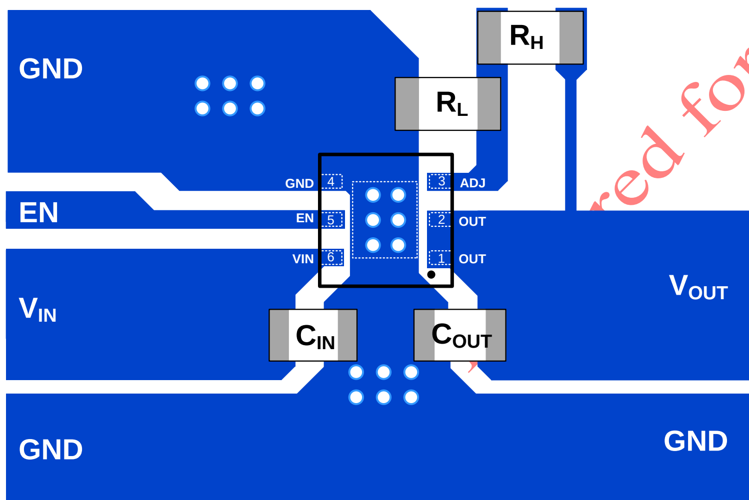
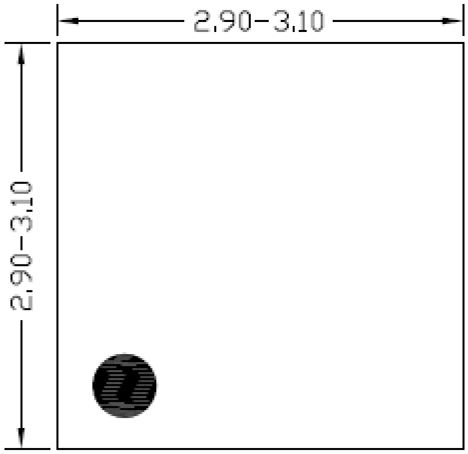
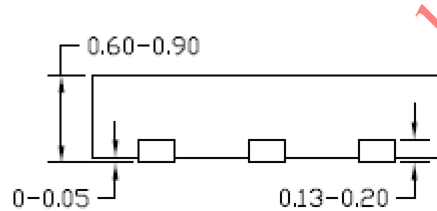


Figure3. PCB Layout Suggestion

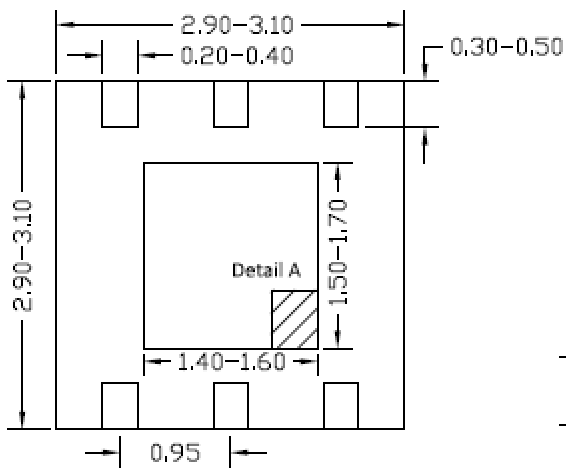
DFN3×3-6 Package Outline Drawing

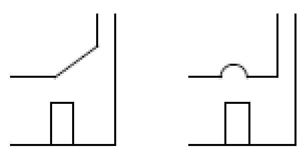


Top View



Side View





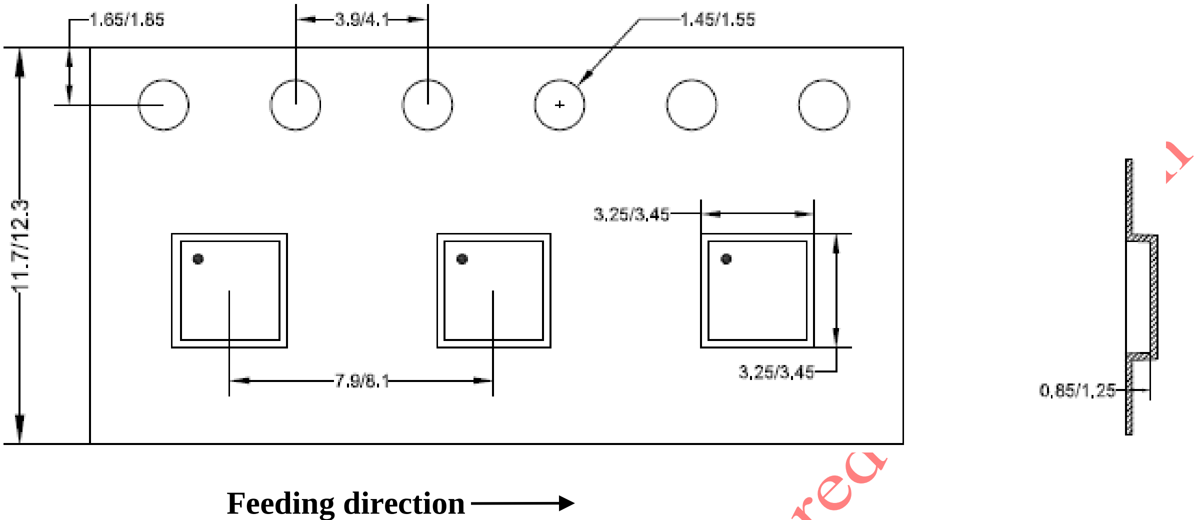
Detail A
Pin1 Identifier: two options

Bottom View

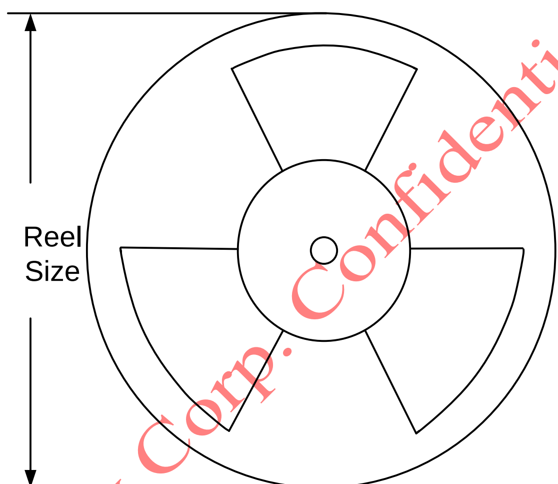
Notes: **All dimension in millimeter and exclude mold flash & metal burr**

Taping & Reel Specification

1. DFN3×3 taping orientation



2. Carrier Tape & Reel specification for packages



Package type	Tape width (mm)	Pocket pitch(mm)	Reel size (Inch)	Trailer length(mm)	Leader length (mm)	Qty per reel
DFN3×3	12	8	13"	400	400	5000

3. Others: NA